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NATIONAL DAM INSPECTION PROGRAM. SHIRF'S RUN DAM, OHIO RIVER BA--ETC(U)
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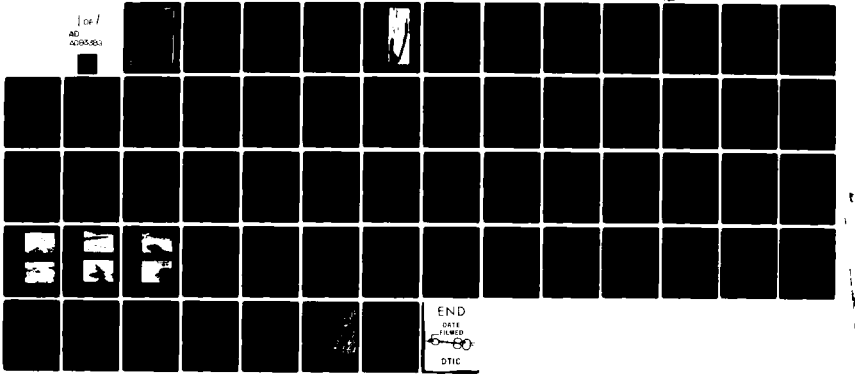

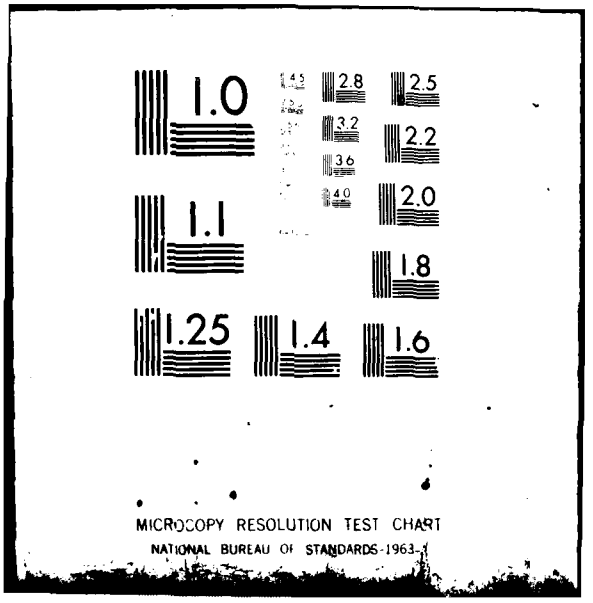
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OHIO RIVER BASIN,
UNNAMED TRIBUTARY OF NORTH BRANCH BLACKLICK CREEK,
CAMBRIA COUNTY,

PENNSYLVANIA

LEVEL

[redacted]
NDI I.D. No. PA-00438,
DER I.D. No. 11-71,
Number

PHASE I INSPECTION REPORT,
NATIONAL DAM INSPECTION PROGRAM

(10) Lawrence D/Andersen

(11) 5 May 80

(12) 61

(15) DACW-31-80-C-0022

PREPARED FOR

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS
BALTIMORE, MARYLAND 21203

BY

D'APPOLONIA CONSULTING ENGINEERS
10 DUFF ROAD
PITTSBURGH, PA. 15235

411001

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Department of the Army, Office of Chief of Engineers, Washington, D.C. 20314.

The purpose of a Phase I investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon visual observations and review of available data. Detailed investigations and analyses involving topographic mapping, subsurface investigations, material testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the inspection is intended to identify any need for such studies which should be performed by the owner.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of the dam depends on numerous and constantly changing internal and external factors which are evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected and only through continued care and maintenance can these conditions be prevented or corrected.

Phase I inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established Guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

The assessment of the conditions and recommendations was made by the consulting engineer in accordance with generally and currently accepted engineering principles and practices.

PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

NAME OF DAM: Shirf's Run Dam
STATE LOCATED: Pennsylvania
COUNTY LOCATED: Cambria
STREAM: Unnamed Tributary of the North Branch of Black Lick Creek
SIZE CLASSIFICATION: Small
HAZARD CLASSIFICATION: High
OWNER: Spangler Municipal Water Authority
DATE OF INSPECTION: November 27 and December 28, 1979

ASSESSMENT: Based on the evaluation of the existing conditions, the condition of Shirf's Run Dam is considered to be good. The only condition noted which requires attention is the lack of adequate erosion protection on the left side of the emergency spillway channel against the embankment. This condition is considered to pose breach potential in the event of large flows through the spillway.

The flood discharge capacity of the dam was evaluated according to the recommended procedure and was found to pass approximately 50 percent of the probable maximum flood (PMF) without overtopping the embankment. This capacity fulfills the lower limit of the recommended spillway capacity range of 50 percent to full PMF. The lower limit was considered to be applicable relative to the size and hazard classification of the dam. Therefore, according to the recommended criteria, the flood discharge capacity of the dam is classified to be adequate.

The following recommendations should be implemented as soon as possible or on a continuing basis:

1. The owner should retain a professional engineer to develop a means for providing erosion protection on the embankment side of the spillway discharge channel, to reshape the spillway discharge channel, and to repair the concrete spillway sill.

2. The crest of the dam should be surveyed and the low spot filled to design elevation.

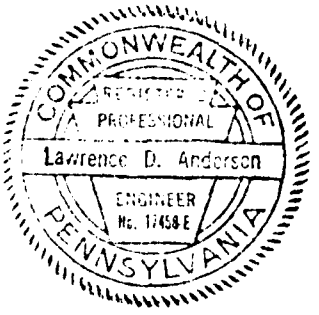
3. The owner should confirm the operational condition of the sluice gate at the upstream end of the outlet pipe and develop a means for operating this gate. If such a gate does not

exist, other means for providing upstream control of the outlet pipe should be developed.

4. Seepage near the left abutment should be monitored to determine changes in flow and development of turbidity.

5. Around-the-clock surveillance should be provided during unusually heavy runoff and a formal warning system developed to alert the downstream residents in the event of emergencies.

6. The dam and appurtenant structures should be inspected regularly and necessary maintenance performed. A review of the regional geology indicates that some deep coal mine workings exist in the vicinity of the dam site. Therefore, future inspections should include a search for any indications of subsidence.



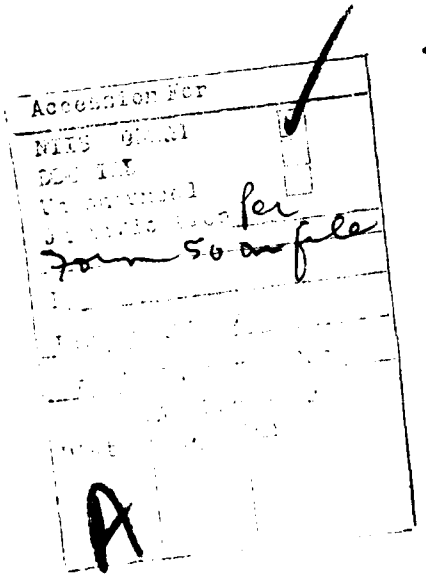
Lawrence D. Andersen, P.E.
Vice President

March 5, 1980
Date

Approved by:

JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

31 March 1980
Date



SHIRF'S RUN DAM
NDI I.D. PA-438
NOVEMBER 27, 1979

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM
SHIRF'S RUN DAM
NDI I.D. PA-438
DER I.D. 11-71

SECTION 1
PROJECT INFORMATION

1.1 General

a. Authority. The inspection was performed pursuant to the authority granted by The National Dam Inspection Act, Public Law 92-367, to the Secretary of the Army, through the Corps of Engineers, to conduct inspections of dams throughout the United States.

b. Purpose. The purpose of this inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 Description of Project

a. Dam and Appurtenances. Shirf's Run Dam consists of an earth embankment approximately 320 feet long with a maximum height of 15 feet from the downstream toe and a crest width of 10 feet. The upstream side of the dam is protected by riprap and the downstream slope is covered with grass. The spillway discharge facilities for the dam consist of an earth channel located at the right abutment. The control section of the spillway is located approximately 100 feet upstream from the axis of the dam, where the channel is about 77 feet wide. At the control section, a 2-foot-wide concrete sill constitutes the overflow section of the spillway. The spillway discharge channel is an unprotected earth channel which terminates at a plunge pool at the toe level of the dam near the right abutment. The outlet facilities consist of a 12-inch cast-iron pipe encased in concrete through the embankment. The outlet pipe is equipped with reinforced concrete cutoff collars. Flow through the outlet pipe is controlled by an automatic valve with a manual override located on the downstream side. This outlet facility constitutes the emergency drawdown system for the reservoir.

b. Location. Shirf's Run Dam is located on an unnamed tributary of the North Branch of Black Lick Creek, which is locally known as Shirf's Run, and is approximately one-half mile upstream from its confluence with the North Branch of Black Lick Creek in Barr Township, Cambria County, Pennsylvania. Plate 1 illustrates the location of the dam.

c. Size Classification. Small (based on 15-foot height and 124 acre-feet storage capacity).

d. Hazard Classification. The dam is classified to be in the high hazard category. One residence and a commercial building are located approximately two miles from the dam. It is estimated that failure of the dam would cause loss of a few lives and some property damage. Based on this damage estimate, the dam is considered to be marginally into the high hazard classification

e. Ownership. Spangler Municipal Water Authority (address: Mr. John Weymer, Jr., Manager, Spangler Municipal Water Authority, P.O. Box 488, Spangler, Pennsylvania 15775).

f. Purpose of Dam. Water supply.

g. Design and Construction History. The dam was designed by Gannett, Seely, and Fleming Engineers, Inc., of Harrisburg, Pennsylvania. The construction of the dam was completed in 1925.

h. Normal Operating Procedure. The reservoir is normally maintained at or below the uncontrolled primary crest level by a self-activating automatic outlet pipe valve. When inflow into the lake is in excess of the capacity of the outlet pipe, flow is discharged through the uncontrolled spillway. In the design drawings, the normal pool level is shown to be at Elevation 1811. However, on the U.S. Geological Survey (USGS) Colver 7-1/2-minute quadrangle map, photorevised 1972, the pool elevation is shown to be at Elevation 1820. Therefore, it appears that the elevations shown on the design drawings are relative to a datum different than the current USGS datum.

1.3 Pertinent Data. Elevations referred to in this and subsequent sections of this report are calculated based on approximate field measurements assuming the spillway crest levels (normal pool level) to be at Elevation 1820 (USGS Datum).

a.	Drainage Area	2.2 square miles
b.	Discharge at Dam Site (cfs)	
	Maximum known flood at dam site	Unknown
	Outlet conduit at maximum pool	10+
	Gated spillway capacity at maximum pool	Not applicable
	Ungated spillway capacity at maximum pool	2055
	Total spillway capacity at maximum pool	2055
c.	Elevation (USGS Datum) (feet)	1825.0 (Design)
	Top of dam	1824.2 (measured low spot)
	Maximum pool	1824.2

Normal pool	1820
Upstream invert outlet works	1810±
Downstream invert outlet works	1799±
Streambed at center line of dam	1800±
Maximum tailwater	Unknown
Toe of dam	1809±

d. Reservoir Length (feet)

Normal pool level	1300
Maximum pool level	1400±

e. Storage (acre-feet)

Normal pool level	61
Maximum pool level	124

f. Reservoir Surface (acres)

Normal pool level	6.4
Maximum pool level	11±

g. Dam

Type	Earth
Length	320 feet
Height	15 feet
Top width	10 feet
Side slopes	Downstream: 2H:1V; Upstream: 2H:1V
Zoning	No
Impervious core	No
Cutoff	No
Grout curtain	No

h. Regulating Outlet

Type	12-inch cast-iron pipe
Length	130± feet
Closure	Automatic gate valve
Access	Valve chamber
Regulating facilities	Automatic gate valve

i. Spillway

Type	Trapezoidal earth channel
Length	77 feet (perpendicular to flow)
Crest elevation	1820
Upstream channel	Lake
Downstream channel	Trapezoidal earth channel

SECTION 2
DESIGN DATA

2.1 Design

a. Data Available. The available data consist of files provided by the Commonwealth of Pennsylvania, Department of Environmental Resources (PennDER) which contain design drawings, correspondence, and inspection reports.

(1) Hydrology and Hydraulics. The available information includes the design capacity of the spillway.

(2) Embankment. The available information consists of design drawings.

(3) Appurtenant Structures. Available information consists of design drawings.

b. Design Features

(1) Embankment. As illustrated in Plate 2, the dam is an homogeneous embankment. Plate 2 also indicates that at least six borings were drilled along the axis of the dam for a subsurface investigation. A section of Plate 3 illustrates the subsurface profile. According to this profile, foundation rock defined as shale was found close to the ground surface at the left side of the valley (looking downstream) and at a depth of 20 to 30 feet near the right abutment. A state report prepared upon the review of the design drawings in 1925 indicates that the embankment was to be placed directly on the ground surface on the sections where sufficient overburden exists above the foundation rock and the cutoff trench was to be excavated to impervious layers where foundation rock is close to the ground surface.

(2) Appurtenant Structures. The appurtenant structures consist of an open channel spillway, located on the right abutment, and outlet works. The layout of the spillway is illustrated in Plate 2. The spillway consists of a trapezoidal earth channel which terminates at a plunge pool at the toe level of the dam. The control section of the spillway is located at the upstream end of the spillway channel where a 2-foot-wide, 3-foot-deep, reinforced concrete wall constitutes the overflow section. The profile of the spillway is illustrated in Plate 3. As it presently exists, the spillway channel has no erosion protection. It terminates at a plunge pool at about the toe level of the dam near the right abutment.

The outlet facilities consist of a 12-inch cast-iron pipe encased in concrete through the embankment. Two reinforced concrete cutoff

collars were provided along the outlet pipe for seepage control. The design drawings indicate that the upstream end of the outlet pipe is equipped with a reinforced concrete intake structure which incorporates a sluice gate for upstream flow control and trash racks and screens. The outlet pipe terminates at a discharge channel approximately 150 feet downstream from the toe of the dam. Flow through this pipe is controlled by a valve located at the downstream end. When the downstream valve is closed, discharge is diverted to a pump station which supplies the distribution system. As it presently exists, the downstream valve is an automatic valve which maintains the reservoir at or below the spillway crest level.

c. Design Data

(1) Hydrology and Hydraulics. A state report entitled, Report Upon the Application of Northern Cambria Water Company, dated October 5, 1925, indicates that the spillway was sized to pass a discharge of 1100 cfs at a depth of 3.2 feet, leaving a freeboard of 1.8 feet to the top of the dam.

(2) Embankment. No engineering data are available on the design of the embankment.

(3) Appurtenant Structures. No design information is available on the appurtenant structures.

2.2 Construction. Very limited information is available on the construction of the dam. According to a 1925 state report, the embankment material was to be deposited in 6-inch layers and rolled with a 10-ton roller.

According to the water authority personnel, the only post-construction change undertaken was the reshaping of the earth spillway channel following a flood in 1977. A state inspection conducted following the 1977 flood reported that the spillway channel received significant scour damage and a scour hole approximately 40 feet in diameter and 20 feet deep was located about 100 feet downstream from the spillway control section.

2.3 Operation. There are no formal operating records maintained for the dam.

2.4 Other Investigations. Spangler Water Authority personnel, in reference to an existing excavation into the left hillside above the dam crest level, reported that to their knowledge, shortly after completion of the dam, an investigation was undertaken to determine the source of the seepage through the left abutment. Reportedly, a test pit was excavated into the left abutment in line with the axis

of the dam and was backfilled with clay. In the available documents, no reference was found to this post-construction investigation. State inspections conducted during the period from 1927 through 1933 refer to the presence of extensive seepage on the left abutment of the dam. However, after a 1935 inspection, no reference was made to this seepage condition, indicating that remedial measures may have been undertaken during the period between 1933 and 1935.

2.5 Evaluation

a. Availability. The available information was provided by PennDER.

b. Adequacy

(1) Hydrology and Hydraulics. The available information consists of the design discharge capacity of the spillway. This information is not considered to be sufficient to assess the adequacy of the spillway.

(2) Embankment. The dam was apparently constructed in accordance with the design drawings. In view of the age of the dam, completed in 1928, the design approach and construction techniques are not likely to be in conformance with currently accepted engineering practices. The design lacks such considerations as embankment slope stability and seepage analysis and other quantitative data to aid in the assessment of the adequacy of design.

(3) Appurtenant Structures. The spillway design is considered to be inadequate due to the lack of adequate erosion protection provisions. Design of the outlet facilities which incorporates reinforced concrete encasement for the outlet pipe and cutoff collars and upsteam flow control is considered to be adequate. However, the operational condition of the upstream control needs to be confirmed.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. General. The on-site inspection of Shirf's Run Dam consisted of:

1. Visual inspection of the embankment, abutments, and embankment toe.

2. Visual examination of the spillway and the visible portions of the outlet works.

3. Evaluation of downstream area hazard potential.

The specific observations are illustrated in Plate 4.

b. Embankment. The general inspection of the embankment consisted of searching for indications of structural distress, such as cracks, subsidence, bulging, wet areas, seeps and boils, and observing general maintenance conditions, vegetative cover, erosion, and other surficial features.

In general, the condition of the embankment is considered to be good. Other than a seepage condition on the left abutment, which was reported to have existed in the past, no other seepage locations were found. Seepage from the left abutment, which flows into a small stream along the left side of the valley over a distance of 100 feet, was estimated to be on the order of 40 to 50 gallons per minute.

The crest of the dam was surveyed relative to the spillway crest elevation and it was found to be on the order of four to six inches below the design elevation. The dam crest profile is illustrated in Plate 5. Field measurements indicate that the downstream face of the dam is on a 2 horizontal to 1 vertical slope.

c. Appurtenant Structures. The most significant condition noted in the spillway structures was the lack of erosion protection on the embankment side of the spillway discharge channel. This condition is considered to pose a breach potential as large flows through the spillway could erode the embankment. The concrete overflow sill at the upstream end of the spillway channel was found to be cracked and structurally in poor condition.

The only visible portion of the outlet works was the automatic valve located at the downstream end of the outlet pipe. The outlet pipe was found to be flowing full.

d. Reservoir Area. A map review indicates that the watershed is covered by pasture and woodlands. A review of the regional geology (Appendix F) indicates that the shorelines of the reservoir are not likely to be susceptible to massive landslides, which might affect the storage volume of the reservoir. This review also indicated that deep coal mine workings may be present in the vicinity of the dam site.

e. Downstream Channel. Below the dam, Shirf's Run flows southwest, joining the North Branch of Black Lick Creek about one mile downstream from the dam. The North Branch then flows west joining the main stem of Black Lick Creek four miles downstream from Shirf's Run Dam. The only inhabitable structures in this reach are located about two miles from the dam and consist of one residence and a commercial building. A further description of the downstream conditions is included in Section 1.2d.

3.2 Evaluation. The condition of Shirf's Run Dam is considered to be good. The only significant condition noted which requires further attention is the lack of erosion protection on the embankment side of the spillway channel. It is considered advisable that the spillway channel be reshaped in conjunction with this work, and the concrete sill at the upstream end should be repaired.

The design drawings indicate that the upstream end of the outlet pipe is equipped with a sluice gate. However, it appears that presently there are no means to operate this gate. Therefore, the owner should confirm the operational condition of this upstream control and develop a means of operation.

SECTION 4
OPERATIONAL FEATURES

4.1 Procedure. There are no formal operating procedures for the dam. The reservoir is normally maintained at or below the spillway crest level by the automatic valve on the outlet pipe. Inflow into the reservoir in excess of the capacity of the outlet pipe is discharged through the uncontrolled spillway.

4.2 Maintenance of the Dam. The maintenance of the dam is considered to be fair. The downstream face of the dam is covered with grass and appears to be periodically mowed. The spillway overflow sill was found to be in poor condition, indicating that it has not been maintained in the past.

4.3 Maintenance of Operating Facilities. The only visible operating facility was the automatic valve located at the downstream end of the outlet pipe. This valve was found to be in good condition.

4.4 Warning System. No formal warning system exists for the dam. Telephone communication facilities are available via residences approximately one mile upstream from the dam.

4.5 Evaluation. The maintenance of the dam is considered to be fair. As discussed previously, it is considered advisable to place erosion protection in the spillway channel, reshape the channel, and repair the concrete overflow structure in the spillway.

SECTION 5
HYDRAULICS AND HYDROLOGY

5.1 Evaluation of Features

a. Design Data. Shirf's Run Dam has a watershed area of 2.2 square miles and impounds a reservoir with a surface area of 6.4 acres at normal pool level. The flood discharge facilities for the dam consist of a trapezoidal earth channel located on the right abutment. The capacity of the spillway was estimated to be 2055 cfs based on 4.2 feet of available freeboard relative to the low spot on the crest of the dam.

b. Experience Data. As previously stated, Shirf's Run Dam is classified as a small dam in the high hazard category. Under the recommended criteria for evaluating emergency spillway discharge capacity, such impoundments are required to pass half to full PMF. In view of the height and storage capacity of the dam, which corresponds to the lower limit of the small size classification, and because the dam was found to be marginally into the high hazard category, the lower limit of the spillway design flood range is considered to be applicable to the dam.

The PMF inflow hydrograph for the reservoir was determined utilizing the Dam Safety Version of the HEC-1 computer program developed by the Hydrologic Engineering Center of the U.S. Army, Corps of Engineers. Data used for the computer analysis are presented in Appendix D. The inflow hydrographs were found to have peak flows of 4217 and 2109 cfs for full and 50 percent of PMF, respectively. Computer input and a summary of computer output are also included in Appendix D.

c. Visual Observations. No conditions were observed that would indicate that the capacity of the spillway would be significantly reduced in the event of a flood.

d. Overtopping Potential. Various percentages of the PMF inflow hydrograph were routed through the reservoir, and it was found that the spillway can pass slightly less than 50 percent of the PMF without overtopping the low spot on the crest of the dam. To obtain an upper bound on the maximum pool level, the spillway discharge rating was conservatively based on a rectangular cross section with the base of the rectangle taken equal to the base of the trapezoidal spillway cross section. For 50 percent of the PMF, it was found that the low area on the embankment would be overtopped for a duration of less than one hour with a maximum depth of 0.04 foot. This overtopping is considered to be insignificant, and therefore, the spillway capacity is rated to be 50 percent of the PMF. It should be noted that filling of the low spots on the crest of the dam would increase the spillway capacity to 50 percent of the PMF with no overtopping.

e. Spillway Adequacy. The spillway capacity was found to fulfill the recommended spillway design capacity and is therefore classified as adequate.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

(1) Embankment. As discussed in Section 3, at the time of inspection, the field observations did not reveal any signs of distress that would significantly affect the stability of the dam.

(2) Appurtenant Structures. The spillway discharge channel was found to lack erosion protection. In view of the condition that the embankment forms the left side of the spillway discharge channel, large flows through the spillway may cause erosion of the embankment, thereby introducing a breach potential. Therefore, it is considered advisable that adequate erosion protection be placed in the spillway discharge channel to protect the embankment.

b. Design and Construction Data

(1) Embankment. The dam was designed in 1925 when limited understanding of geotechnical behavior of earth structures existed. The available design and construction information does not provide any quantitative data to aid in the assessment of stability. However, as previously noted, the field observations did not reveal any signs of distress that would significantly affect the stability of the dam at this time, and none were reported in the past. Therefore, based on visual observations, the static stability of the dam is considered to be adequate.

(2) Appurtenant Structures. Other than design drawings, no design and construction data exist for the appurtenant structures.

c. Operating Records. The structural stability of the dam is not considered to be affected by the operational features of the dam.

d. Post-Construction Changes. It is reported that an investigation was undertaken into the cause of a seepage on the left abutment, which was observed several years after the completion of the dam. The description of this work is included in Section 2.2.

e. Seismic Stability. The dam is located in Seismic Zone 1, and based on visual observations, the static stability of the dam is considered to be adequate. Therefore, based on the recommended criteria for evaluation of seismic stability of dams, the structure is presumed to present no hazard as a result of earthquakes.

SECTION 7
ASSESSMENT AND RECOMMENDATIONS/PROPOSED REMEDIAL MEASURES

7.1 Dam Assessment

a. Assessment. The visual observations indicate that except for the condition of the spillway discharge channel, the overall condition of Shirf's Run Dam is good. Due to lack of erosion protection in the spillway discharge channel, large flows through the spillway are considered to pose a potential for erosion of the embankment, thereby threatening the integrity of the dam. Therefore, it is recommended that the spillway discharge channel be provided with adequate erosion protection and reshaped in conjunction with this work.

Spillway capacity was evaluated according to the recommended procedure and was found to pass 50 percent of the PMF. This capacity fulfills the lower limit of the recommended spillway capacity range of 50 percent to full PMF, out of which the lower limit was considered to be applicable relative to the size and hazard classification of the dam. Therefore, the spillway capacity is rated as adequate.

b. Adequacy of Information. The available information, in conjunction with the visual observations and the previous experience of the inspectors, is considered to be sufficient to make the following recommendations.

c. Urgency. The following recommendations should be implemented as soon as possible or on a continuing basis.

d. Necessity for Additional Data. None required.

7.2 Recommendations/Remedial Measures. It is recommended that:

1. The owner should retain a professional engineer to develop a means for providing erosion protection on the embankment side of the spillway discharge channel, to reshape the spillway discharge channel, and to repair the concrete spillway sill.

2. The crest of the dam should be surveyed and the low spot filled to design elevation.

3. The owner should confirm the operational condition of the sluice gate at the upstream end of the outlet pipe and develop a means for

operating this gate. If such a gate does not exist, other means for providing upstream control of the outlet pipe should be developed.

4. Seepage near the left abutment should be monitored to determine changes in flow and development of turbidity.

5. Around-the-clock surveillance should be provided during unusually heavy runoff and a formal warning system developed to alert the downstream residents in the event of emergencies.

6. The dam and appurtenant structures should be inspected regularly and necessary maintenance performed. A review of the regional geology indicates that some deep coal mine workings exist in the vicinity of the dam site. Therefore, future inspections should include a search for any indications of subsidence.

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

APPENDIX A

CHECKLIST
VISUAL INSPECTION
PHASE I

NAME OF DAM Shirf's Run Dam COUNTY Cambria STATE Pennsylvania ID# NDI I.D. PA-438 DER I.D. 11-71

TYPE OF DAM Earth HAZARD CATEGORY High

DATE(S) INSPECTION November 27, 1979 WEATHER Cloudy TEMPERATURE 40s

POOL ELEVATION AT TIME OF INSPECTION 1820 M.S.L. TAILWATER AT TIME OF INSPECTION 1799 M.S.L.

INSPECTION PERSONNEL:

Bilgin Erel

Wah-Tak Chan

REVIEW INSPECTION PERSONNEL:
(December 28, 1979)

E. D'Appolonia

L. D. Andersen

J. H. Poellot

B. Erel

B. Erel RECORDER

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	See Plate 5 for the dam crest profile.	
RIPRAP FAILURES	None	

VISUAL INSPECTION
PHASE I
EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No signs of distress.	
ANY NOTICEABLE SEEPAGE	A seepage area is located near the left abutment. See Plate 4 for location and estimated quantity of seepage.	
STAFF GAGE AND RECORDER	None	
DRAINS	None	

VISUAL INSPECTION
PHASE 1
OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	The outlet pipe is a 12-inch cast-iron pipe. (No portion of the outlet pipe was visible.)	
INTAKE STRUCTURE	Submerged	
OUTLET STRUCTURE	None	
OUTLET CHANNEL	Earth channel	
EMERGENCY GATE	The outlet pipe is equipped with an automatic altitude valve at the downstream end. The pipe was found to be flowing full on the date of inspection.	

VISUAL INSPECTION
PHASE I
UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	A concrete sill. Structurally in poor condition.	Necessary repairs should be performed.
APPROACH CHANNEL	Lake	
DISCHARGE CHANNEL	Trapezoidal earth channel with no erosion protection. Cross section is irregular.	The spillway discharge channel should be provided with adequate erosion protection and should be reshaped.
BRIDGE AND PIERS	None	

VISUAL INSPECTION
PHASE I
GATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SILL	Not applicable	
APPROACH CHANNEL	Not applicable	
DISCHARGE CHANNEL	Not applicable	
BRIDGE PIERS	Not applicable	
GATES AND OPERATION EQUIPMENT	Not applicable	

VISUAL INSPECTION
PHASE I
INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER	None	

VISUAL INSPECTION
PHASE I
RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Gentle to moderately steep. No significant shoreline erosion was noted.	
SEDIMENTATION	Unknown	
UPSTREAM RESERVOIRS	None	

VISUAL INSPECTION
PHASE I
DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	No significant obstructions were found that would affect the discharge capacity of the spillway.	
SLOPES	No features pertinent to the safety of the dam.	
APPROXIMATE NUMBER OF HOMES AND POPULATION	One house and a commercial building are located two miles downstream from the dam. Population: approximately 10.	

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
AND HYDROLOGIC AND HYDRAULIC
PHASE I

APPENDIX B

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Shirf's Run Dam
ID# NDI I.D. PA-438
DER I.D. 11-71

ITEM	REMARKS
AS-BUILT DRAWINGS	Available in state files.
REGIONAL VICINITY MAP	See Plate 1.
CONSTRUCTION HISTORY	The dam was designed by Gannett, Seely, and Fleming, Consulting Engineers, Inc., of Harrisburg, Pennsylvania in 1925. The construction of the dam was completed in 1927.
TYPICAL SECTIONS OF DAM	See Plate 2.
OUTLETS - PLAN - DETAILS - CONSTRAINTS - DISCHARGE RATINGS	See Plates 2 and 3.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
RAINFALL/RESERVOIR RECORDS	Not maintained
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	See Plates 2 and 3.

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION SURVEYS OF DAM	None reported
BORROW SOURCES	Unknown
MONITORING SYSTEMS	None
MODIFICATIONS	None
HIGH POOL RECORDS	Not recorded

CHECKLIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

ITEM	REMARKS
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Reportedly, an investigation was undertaken into the cause of a seepage located on the left abutment several years after the completion of the dam.
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	A state inspection report dated August 3, 1977, indicates that the spillway discharge channel has incurred significant erosion damage during the passage of a flood in 1977.
MAINTENANCE OPERATION RECORDS	Not recorded
SPILLWAY PLAN SECTIONS DETAILS	See Plates 2 and 3.
OPERATING EQUIPMENT PLANS AND DETAILS	See Plate 3.

CHECKLIST
ENGINEERING DATA
HYDROLOGIC AND HYDRAULIC

DRAINAGE AREA CHARACTERISTICS: 2.2 square miles

ELEVATION, TOP OF NORMAL POOL AND STORAGE CAPACITY: 1820 (61 acre-feet)

ELEVATION, TOP OF FLOOD CONTROL POOL AND STORAGE CAPACITY: 1824.2 (124 acre-feet)

ELEVATION, MAXIMUM DESIGN POOL: 1825 (as designed)

ELEVATION, TOP OF DAM: 1824.2 (measured low spot)

SPILLWAY:

a. Elevation 1820

b. Type Trapezoidal earth channel

c. Width 77 feet (at the upstream control section)

d. Length 200± feet (the length of the spillway discharge channel)

e. Location Spillover Near left abutment

f. Number and Type of Gates None

OUTLET WORKS:

a. Type 12-inch cast-iron pipe

b. Location Center of embankment

c. Entrance Inverts 1810±

d. Exit Inverts 1799±

e. Emergency Drawdown Facilities 12-inch outlet pipe

HYDROMETEOROLOGICAL GAGES:

a. Type None

b. Location None

c. Records None

MAXIMUM NONDAMAGING DISCHARGE: 2000± cfs (spillway capacity)

APPENDIX C

PHOTOGRAPHS

LIST OF PHOTOGRAPHS
SHIRF'S RUN DAM
NDI I.D. PA-438
NOVEMBER 27, 1979

PHOTOGRAPH NO.	DESCRIPTION
1	Crest (looking northwest).
2	Spillway crest and approach channel.
3	Spillway discharge channel (in line with axis of dam).
4	Spillway discharge channel (below toe of dam).
5	Outlet pipe discharge channel (pipe submerged).
6	Outlet pipe valve (automatic altitude valve).

Photograph No. 1

Crest (looking northwest).

Photograph No. 2

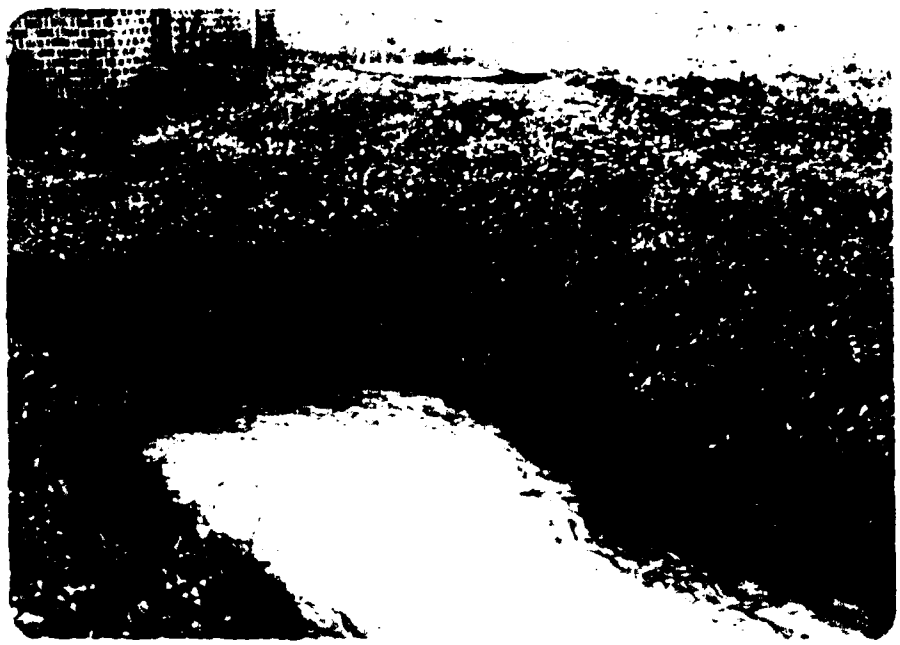
Spillway crest and approach channel.

Photograph No. 3

Spillway crest and approach channel.

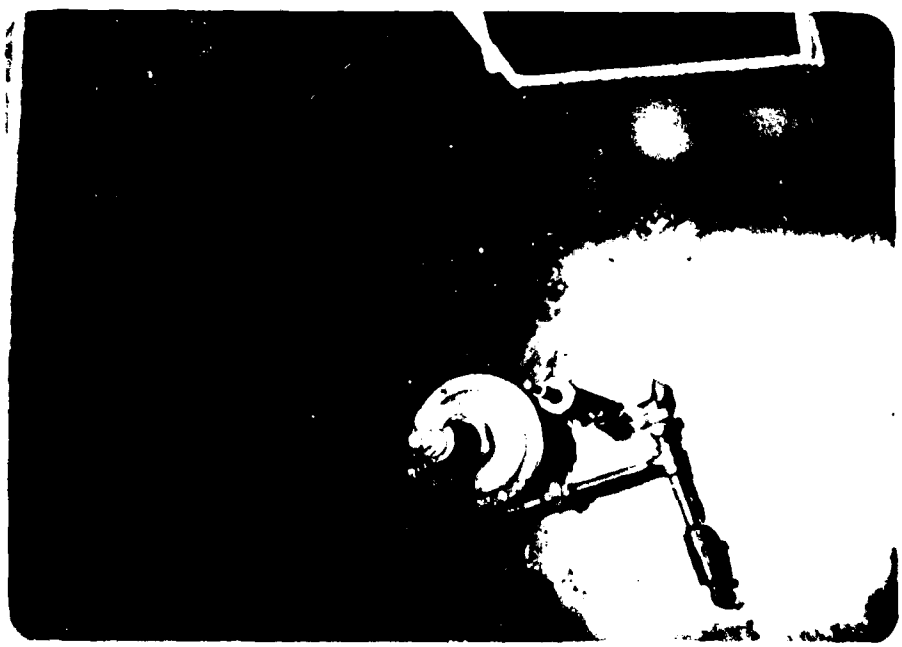
Photograph No. 4

Spillway discharge channel (below toe of dam).



Photograph No. 5

Outlet pipe discharge channel (pipe submerged).



Photograph No. 6

Outlet pipe valve (automatic altitude valve).

APPENDIX D

HYDROLOGY AND HYDRAULICS ANALYSES

HYDROLOGY AND HYDRAULIC ANALYSIS
DATA BASE

NAME OF DAM: Shirf's Run Dam (NDI I.D. PA-438)

PROBABLE MAXIMUM PRECIPITATION (PMP) = 23.6 INCHES/24 HOURS[1]

STATION	1	2	3	4	5
Station Description	Reservoir	Dam			
Drainage Area (square miles)	2.18	-			
Cumulative Drainage Area (square miles)	2.18	2.18			
Adjustment of PMF for Drainage Area (%)[2]	Zone 7				
6 Hours	102	-			
12 Hours	120	-			
24 Hours	130	-			
48 Hours	140	-			
72 Hours	-	-			
Snyder Hydrograph Parameters					
Zone[3]	24	-			
C_p/C_t[4]	0.45/1.6	-			
L (miles)[5]	2.2	-			
L_{ca} (miles)[5]	1.1	-			
$t_p = C_t(L \cdot L_{ca})^{0.3}$ (hours)	2.09	-			
Spillway Data					
Crest length (ft)	-	22			
Freeboard (ft)	-	4.2			
Discharge Coefficient	-	3.1			
Exponent	-	1.5			

[1] Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.

[2] Hydrometeorological Report 33 (Figure 2), U.S. Army, Corps of Engineers, 1956.

[3] Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

[4] Snyder's Coefficients.

[5] L = Length of longest water course from outlet to basin divide.
L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

STORAGE VS ELEVATION

ELEVATION	ΔH, FEET	AREA (ACRES)[1]	VOLUME (ACRE-FEET)[2]	STORAGE (ACRE-FEET)
1840	20	25.7	299.5	360.9
1820[4]		6.4	61.4[3]	61.4
Reservoir Bottom		-		0

[1] Planimetered from USGS maps.

[2] ΔVolume = ΔH/3 ($A_1 + A_2 + \sqrt{A_1 A_2}$).

[3] From PennDER files.

[4] Water elevation obtained from USGS map.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********
     1                A1       SNYDER UNIT HYDROGRAPH,FLOOD ROUTING AND DAM OVERTOPPING ANALYSES
     2                A2       SHIRFS RUN DAM,CAMBRIA COUNTY,NDI-I.D.PA.438     PROJECT NO.79-543-12
     3                A3       FOR 20%,30%,4 %,5 %,40%,70%,80%,90%,AND 100% PMF
     4                B      300          0        15         0          0         0         C        -4         C
     5                B1       5
     6                J        1         9         1
     7                J1    0.20      0.30      0.40      0.50      0.60      0.70      0.80      0.90      1.00
     8                K                  1                                                  1
     9                K1       CALCULATION OF SNYDER INFLOW HYDROGRAPH TO SHIRFS RUN RESERVOIR                  1
    10                M        1         1      2.18                2.18
    11                P                 23.6       102       120       130       140
    12                T                                                                    1.0       .05              0.0046
    13                J     2.09      0.45
    14                K     -1.0     -0.05       2.0                                                  1
    15                K        1         2
    16                K1       ROUTING FLOW THROUGH SHIRFS RUN DAM (NDI-I.D.PA.438)
    17                Y                                              1         1
    18                Y1       1                                                                -1820.0
    19                SS     0.0      61.4     360.9
    20                SE  1800.0    1820.0    1840.0
    21                SS  1822.0      77.0      3.10       1.5
    22                SD  1824.2      3.08       1.5     320.0
    23                SL    35.0     145.0     195.0     245.0     295.0     320.0
    24                SV  1824.2    1824.5    1824.6    1824.8    1825.0    1826.0
    25                K       99
```

COMPUTER INPUT OVERTOPPING ANALYSIS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .20	RATIO 2 .30	RATIO 3 .40	RATIO 4 .50	RATIO 5 .60	RATIO 6 .70	RATIO 7 .80	RATIO 8 .90	RATIO 9 1.00
HYDROGRAPH AT	1	2.18	1	843.	1265.	1687.	2109.	2530.	2952.	3374.	3795.	4217.
	(	5.65)	(	23.88)(	35.83)(	47.77)(	59.71)(	71.65)(	83.59)(	95.53)(	107.48)(	119.42)
ROUTED TO	2	2.18	1	829.	1248.	1666.	2087.	2523.	2947.	3370.	3791.	4212.
	(	5.65)	(	23.48)(	35.34)(	47.19)(	59.09)(	71.44)(	83.46)(	95.41)(	107.35)(	119.27)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	1820.00	1820.00	1824.20
STORAGE	61.	61.	124.
OUTFLOW	0.	0.	2055.

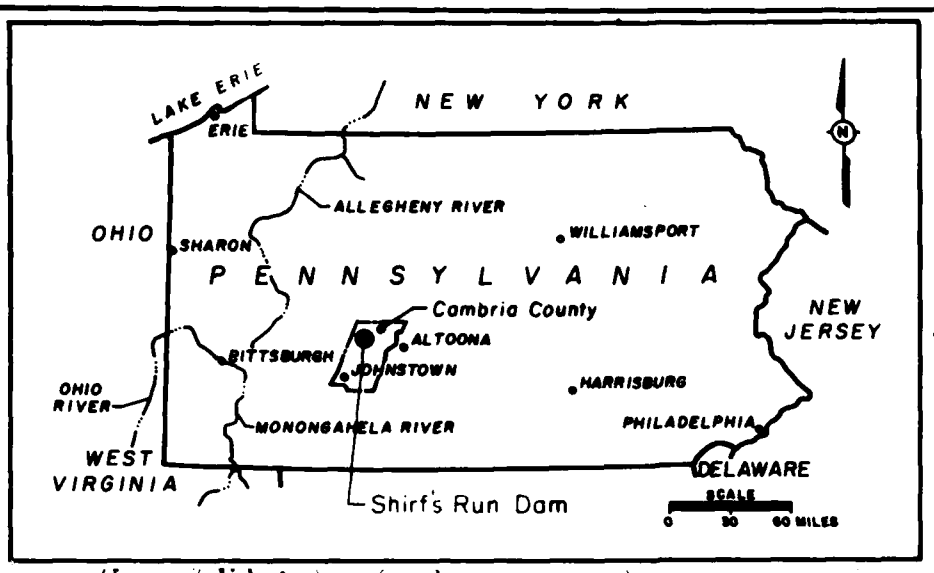
RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.20	1822.29	0.00	96.	829.	0.00	42.25	0.00
.30	1823.01	0.00	107.	1248.	0.00	42.25	0.00
.40	1823.65	0.00	116.	1666.	0.00	42.25	0.00
.50	1824.24	.04	125.	2087.	.75	42.00	0.00
.60	1824.68	.48	131.	2523.	2.50	42.00	0.00
.70	1824.97	.77	136.	2947.	3.75	42.00	0.00
.80	1825.20	1.00	139.	3370.	4.50	42.00	0.00
.90	1825.41	1.21	142.	3791.	5.25	42.00	0.00
1.00	1825.60	1.40	145.	4212.	5.75	42.00	0.00

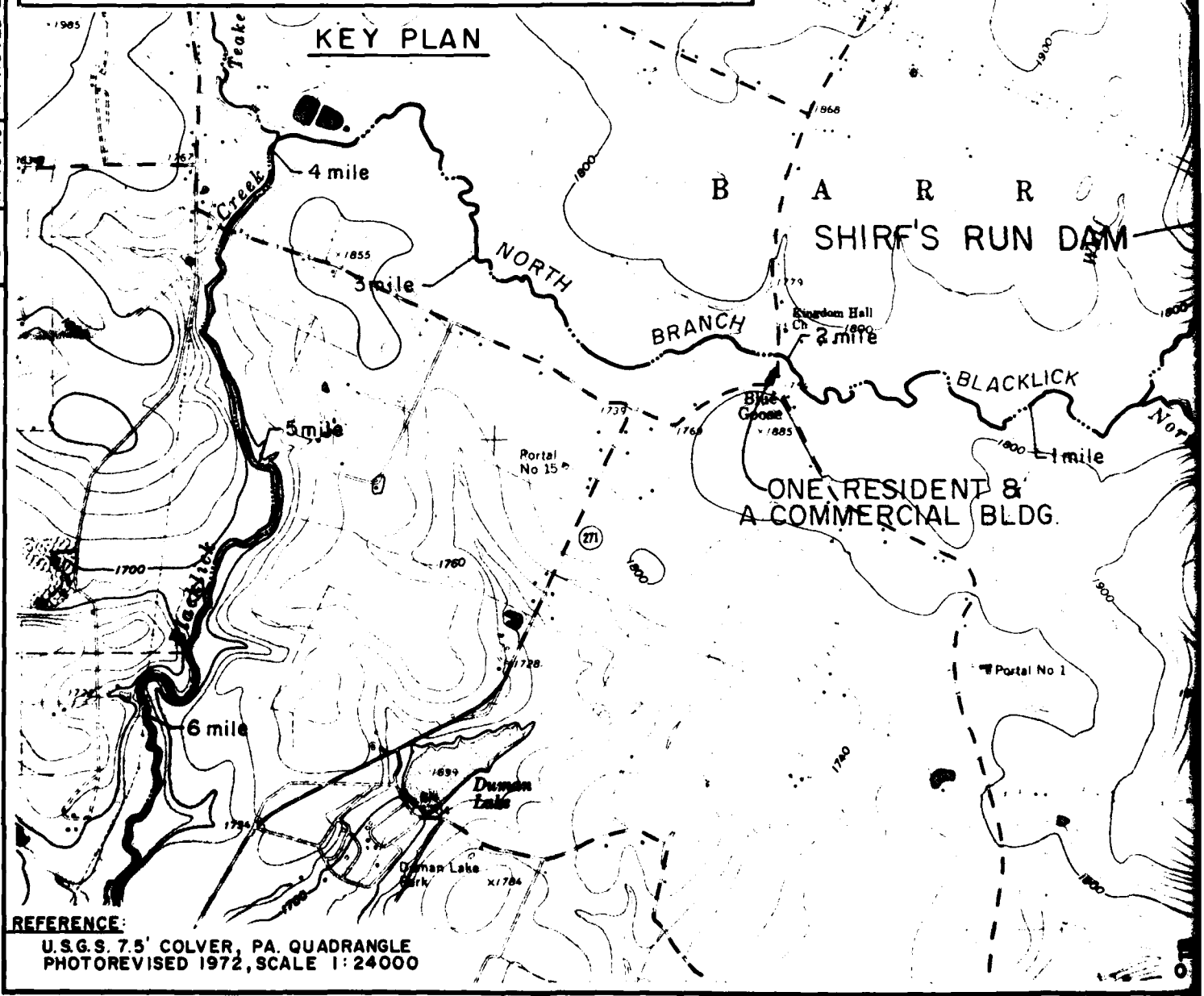
OVERTOPPING ANALYSIS SUMMARY

APPENDIX E

PLATES

DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER 79-543-830
	11-15-79	APPROVED BY		





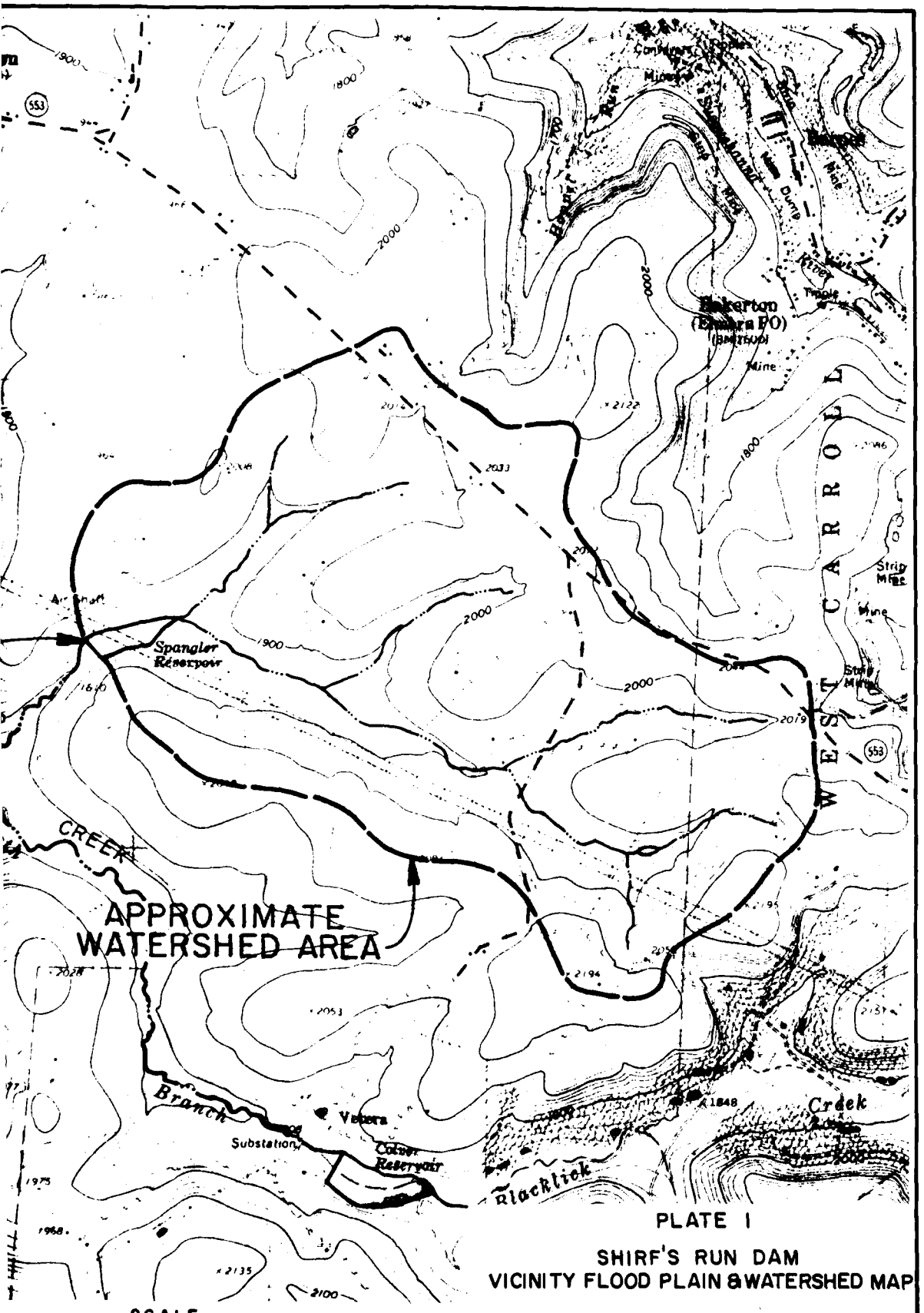


PLATE 1

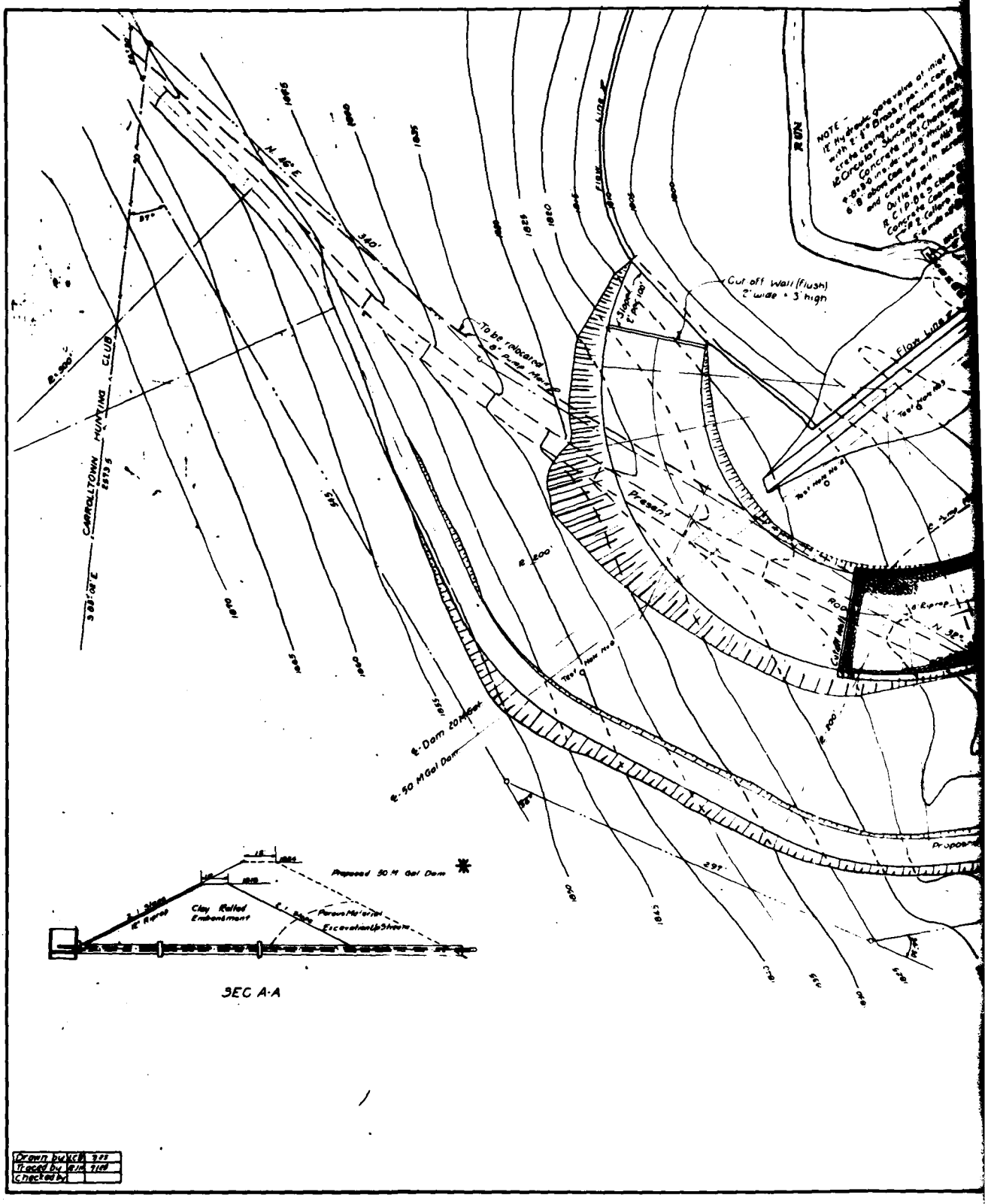
SHIRF'S RUN DAM
VICINITY FLOOD PLAIN & WATERSHED MAP

SCALE
1000 2000 3000 4000 5000 FEET

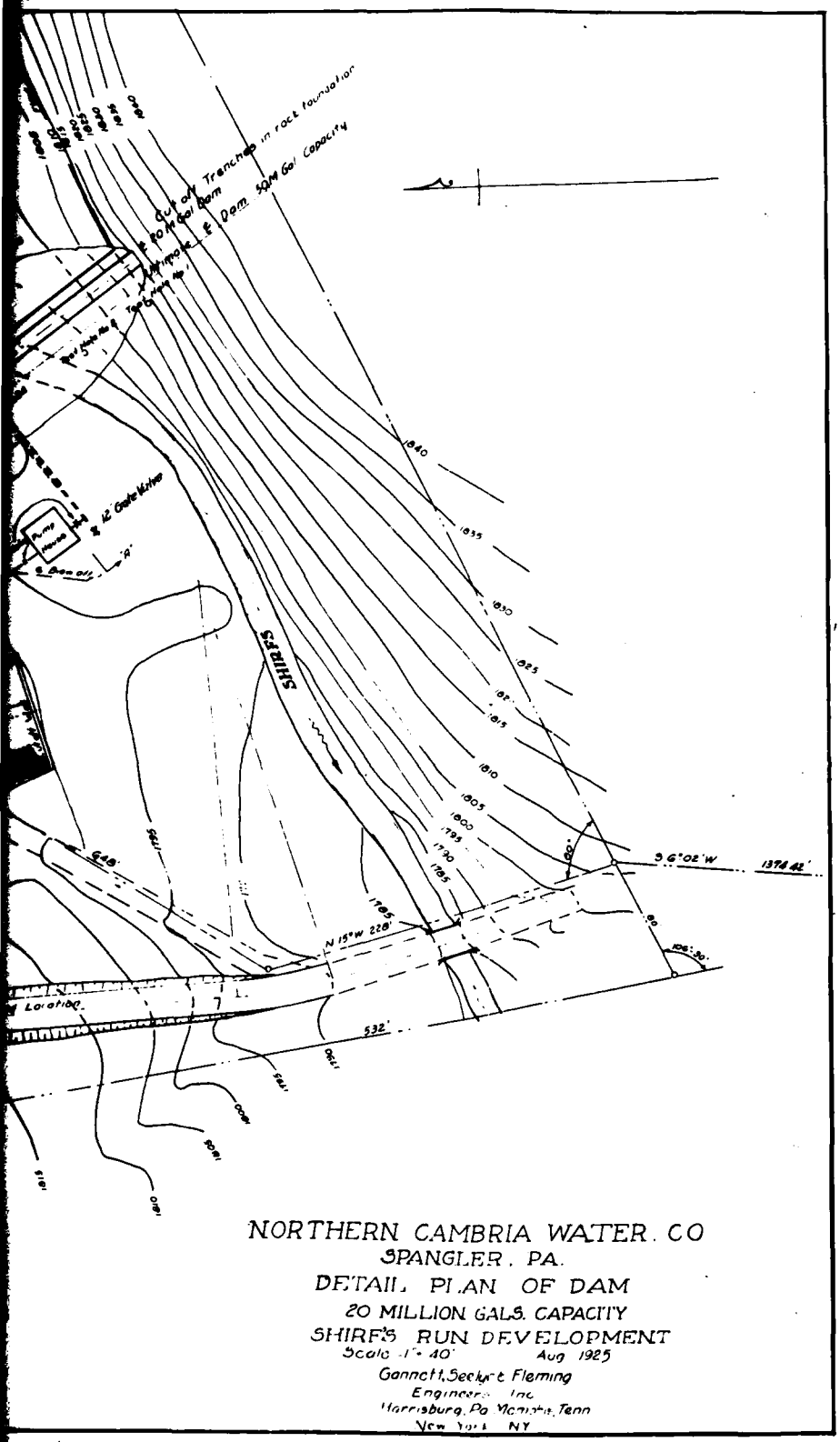
D'APPOLONIA

2

DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER
	11-16-79	APPROVED BY		79-543-B31



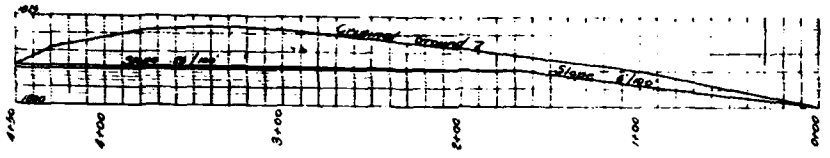
* PROPOSED ENLARGEMENT WAS NOT CONSTRUCTED



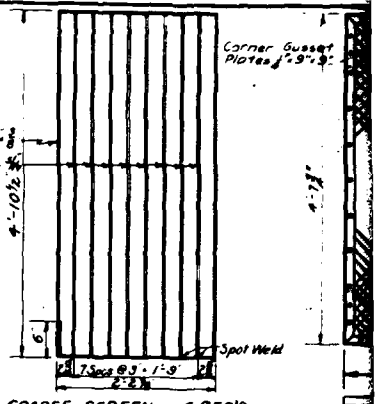
NORTHERN CAMBRIA WATER. CO
SPANGLER. PA.
DETAIL PLAN OF DAM
20 MILLION GALS. CAPACITY
SHIRE'S RUN DEVELOPMENT
Scale 1" = 40' Aug 1925
Gannett, Seelye & Fleming
Engineers Inc.
Harrisburg, Pa Memphis, Tenn
New York NY

PLATE 2

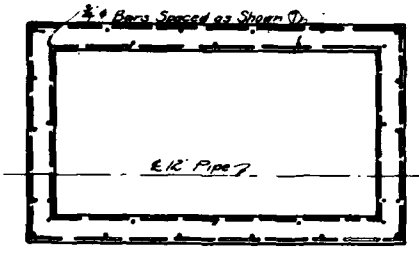
DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
ACS 11-16-79			79-343-B32



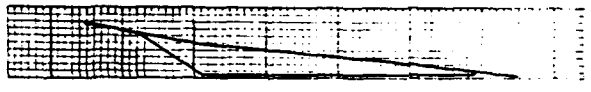
PROFILE ALONG ℄ OF SPILLWAY



COARSE SCREEN *REQ'D



RE-INFORCING PLAN



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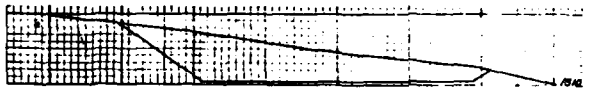

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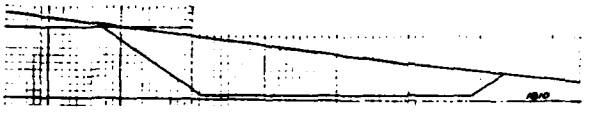
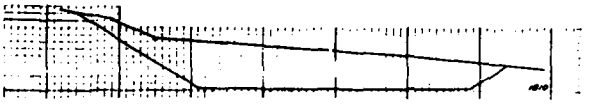


Sta. 3+50



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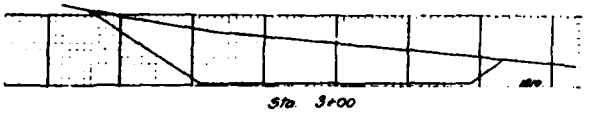
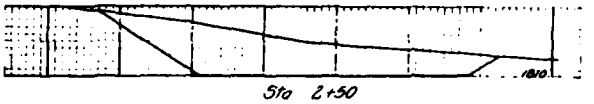
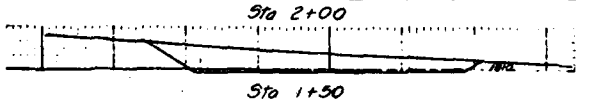


Sta. 3+00



Sta 2+50

Sta 2+00



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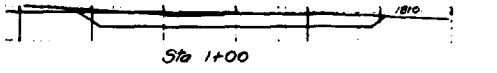

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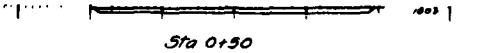

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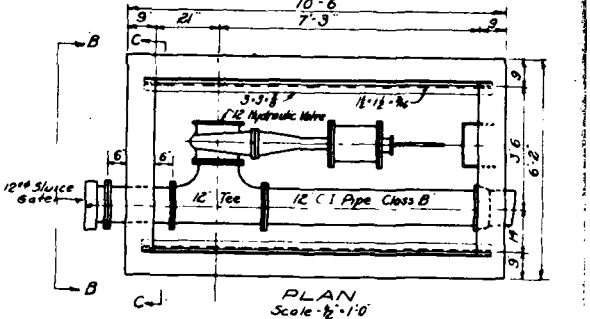
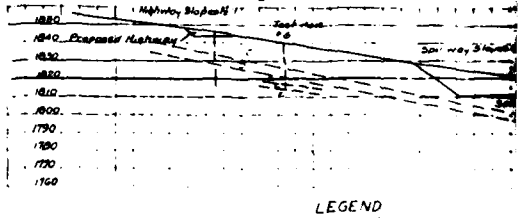
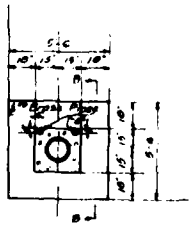
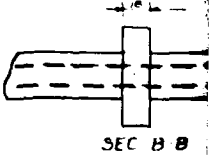


PLAN
Scale-½"=1'0"



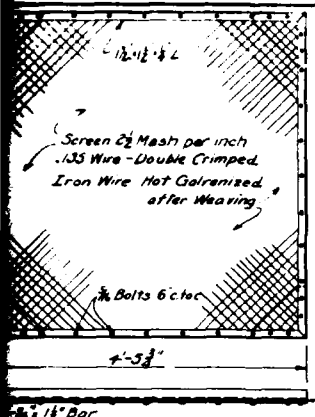
LEGEND
A - COARSE SILT
B - GRAVEL - STONE
C - CLAY
D - SOFT SHALE
E - SOLID SHALE





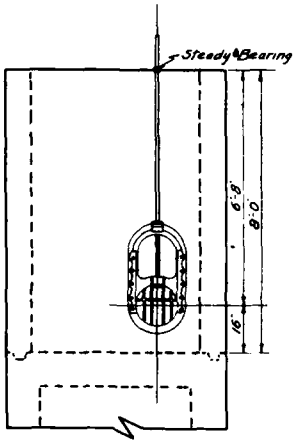
SEC B B

Drawn by	CW	7/80
Traced By	PJB	7/81
Checked By		



MARK	SIZE	QUANTITY	TOTAL LENGTH	DESCRIPTION
1	½ ϕ	14	16'-3	5'-3"
2	¾ ϕ	8	16'-3	5'-3"
3-A	¾ ϕ	3	10'-6"	3'-3"
3-B	¾ ϕ	3	14'-9"	3'-3"
4	½ ϕ	14	18'-3"	10'-3"
5	¾ ϕ	8	18'-3"	10'-3"
6-A	¾ ϕ	3	12'-6"	10'-3"
6-B	¾ ϕ	3	16'-9"	10'-3"
7	¾ ϕ	32	7'-7"	Straight
8	½ ϕ	10	6'-0	Straight
9	½ ϕ	5	10'-3	Straight

FINE SCREEN 2 REQ'D.
Scale - 1" = 1'-0"



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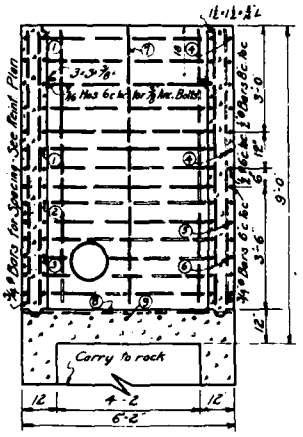

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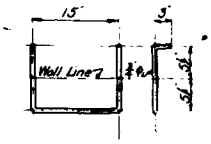
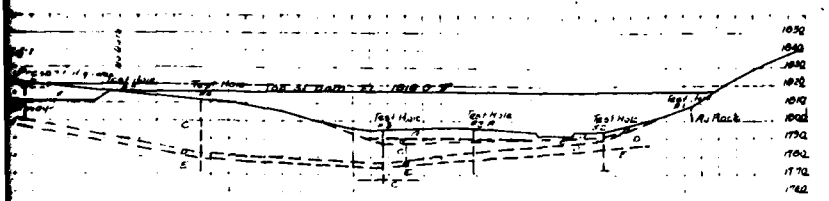


LADDER RUNG
6 Req'd. Scale 1"-1'-0"



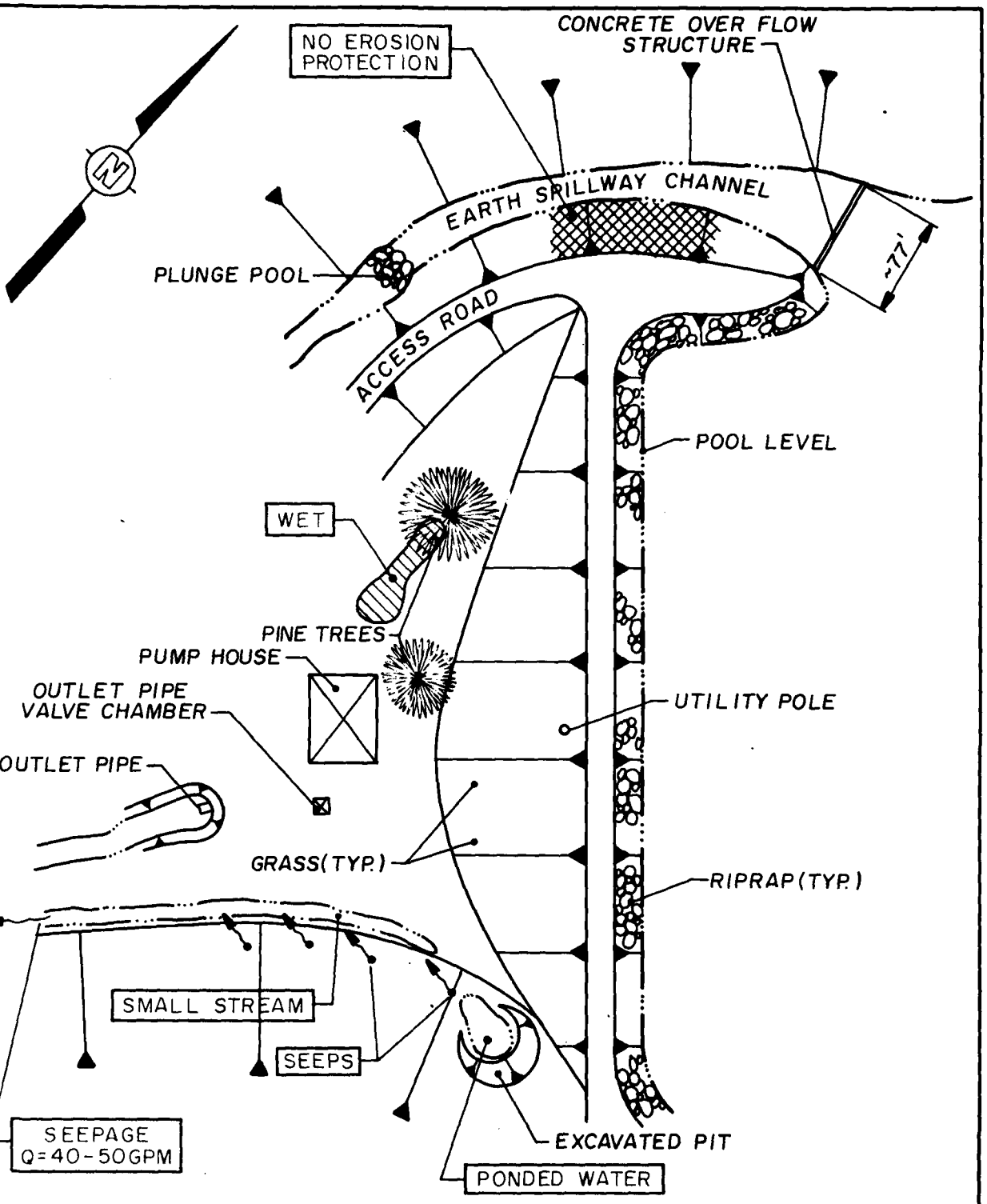
LONGITUDINAL SECTION
ON ℄ OF DAM
Scale - 1" = 40'

NORTHERN CAMBRIA WATER. CO.
SPANGLER. PA.
SPILLWAY-INTAKEWELL & PIPING
SHIRF'S RUN DEVELOPMENT

PLATE 3

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	BE	DRAWING NUMBER	79-J-A25
	11-15-79	APPROVED BY	JMD		



NOTES:

1. POOL LEVEL DATE OF INSPECTION: 1.0 FT. ABOVE SPILLWAY STRUCTURE CREST.

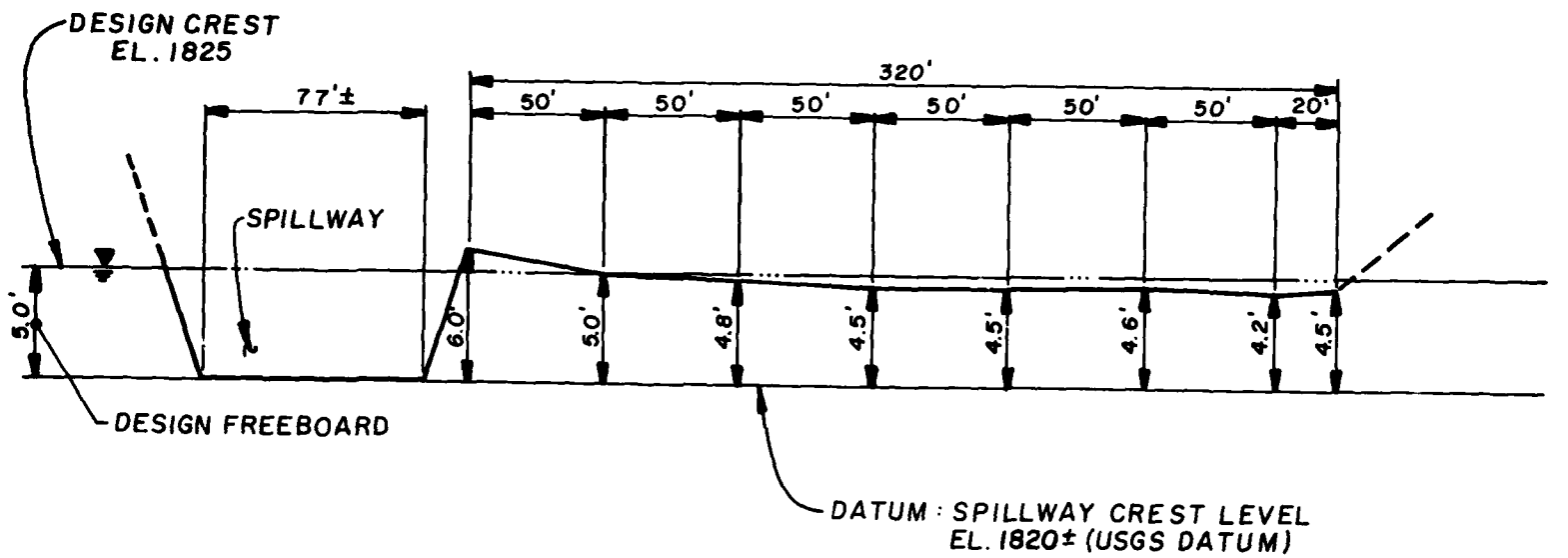
NOT TO SCALE

PLATE 4

SHIRF'S RUN DAM
GENERAL PLAN
FIELD INSPECTION NOTES
FIELD INSPECTION DATE: NOV. 27, 1979

D'APPOLONIA

DRAWN BY	ACS	CHECKED BY	BE	2/19/80	DRAWING NUMBER 79-C-3-A26
	11-15-79	APPROVED BY	JAP	2/14/80	



DAM CREST PROFILE

(LOOKING DOWNSTREAM)

NOTES:

1. DAM CREST IS SURVEYED RELATIVE TO SPILLWAY CREST LEVEL
2. DATUM ELEVATION IS INTERPOLATED FROM A USGS MAP IS THEREFORE APPROXIMATE

SHIRF'S RUN DAM
DAM CREST SURVEY
FIELD INSPECTION DATE: NOV. 27, 1979

PLATE 5

DEPARTMENT OF THE ARMY

APPENDIX F

REGIONAL GEOLOGY

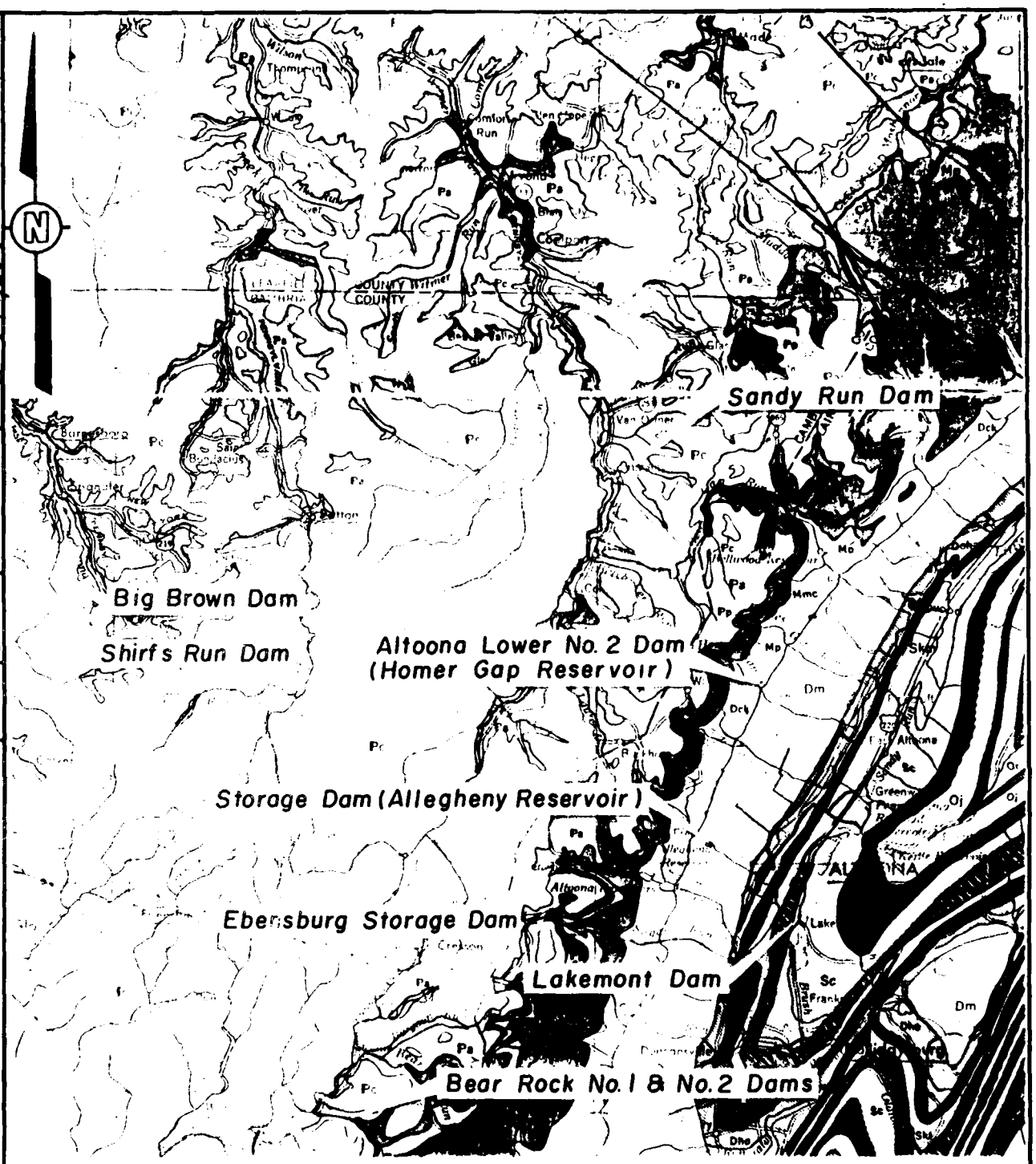
APPENDIX F

REGIONAL GEOLOGY

Shirf's Run Dam physiographically lies within the Allegheny Mountains section of the Appalachian Plateau Province. The dam site is on the west flank of the Laurel Hill anticline, which coincides with the east flank of the Barnesboro syncline in this area. The strata dip approximately 150 feet per mile to the west. Bedrock at the site consists of sedimentary rock strata of the Middle to Lower Conemaugh Group of the Pennsylvania Series. In general, strata of the Conemaugh Group consist of interbedded shale, claystone, sandstone, and several thin coal seams. The underlying Allegheny Group consists of sandstone and shale strata along with several coal seams.

The Lower Kittanning coal seam of the underlying Allegheny Group has been extensively mined in Cambria County. Available information indicates that this seam has been mined in the dam and reservoir area by the Barnes and Tucker Company Lancashire No. 15 works. The mine is located approximately 450 to 500 feet below the surface. A mine shaft was discovered immediately west of the dam and reservoir; however, the actual extent and type of mining operation were not determined. Therefore, depending on the type of mining and local geology, a potential for surface subsidence may exist. The Upper Kittanning and Lower and Upper Freeport coal seams have not been mined in the area.

The slopes in the vicinity of the reservoir are relatively gentle, reflecting the ease of weathering of the fine-grained Conemaugh rock strata. No large slides should occur, although minor creep may be expected.



DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER
	12-31-79	APPROVED BY		79-543-A 13

SCALE

0 2 4 6 8 10 miles

REFERENCE:
GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA, DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

SANDY RUN, BIG BROWN, SHIRFS RUN EBENSBURG STORAGE, LAKEMONT, BEAR ROCK NO. 1 AND NO. 2 DAMS, (ALLEGHENY RESERVOIR) STORAGE DAM AND ALTOONA LOWER NO. 2 (HOMER GAP RESERVOIR)

GEOLOGY MAP

DAPPOLONIA

DRAWN BY	ACS	CHECKED BY		DRAWING NUMBER 79-543-A18
	12-31-79	APPROVED BY		

LEGEND

Pc — **Conemaugh Formation**
Cyclic sequences of red and gray shales and siltstones with thin limestones and coals, massive Mahoning Sandstone commonly present at base; Ames Limestone present in middle of sections, Brush Creek Limestone in lower part of section.

Pottsville Group
Light gray to white, coarse grained sandstones and conglomerates with some mineable coal; includes Sharp Mountain, Schuylkill, and Tumbling Run Formations.

Pa — **Allegheny Group**
Cyclic sequences of sandstone, shale, limestone and coal; numerous commercial coals, limestones thicken westward; Vanport Limestone in lower part of section, includes Freeport, Kittanning, and Clarion Formations.

Sc — **Clinton Group**
Predominantly Rose Hill Formation: Reddish purple to greenish gray, thin to medium bedded, fossiliferous shale with interbedding "iron sandstones" and local gray, fossiliferous limestone, above the Rose Hill is brown to white quartzite sandstone (Keefer) interbedded upward with dark gray shale (Rochester).

Dm — **Marine beds**
Gray to olive brown shales, graywackes, and sandstones; contains "Chemung" beds and "Portage" beds including Burket, Brallier, Harrell, and Trimmers Rock; Tully Limestone at base.

Pocono Group
Predominantly gray, hard, massive, cross-bedded conglomeratic and sandstone with some shale; includes in the Appalachian Plateau Burgoon, Shenango, Cuyahoga, Corry, and Knapp Formations; includes part of "Oswayo" of M.J. Fuller in Potter and Tioga counties.

Oriskany Formation
White to brown, fine to coarse grained, partly calcareous locally conglomeratic, fossiliferous sandstone; Ridgeley at the top, dark gray, cherty limestone with some interbedded shales and sandstones below (shown).

Tuscarora Formation
White to gray, medium to thick bedded, fine grained, quartzitic sandstone, conglomeratic in part.

Marcellus Formation
Black, fissile, carbonaceous shale with thick, brown sandstone (Turkey Ridge) in parts of central Pennsylvania.

Onondaga Formation
Greenish blue, thin bedded shale and dark blue to black, medium bedded limestone with shale predominant in most places; includes Selinsgrove Limestone and Needmore Shale in central Pennsylvania and Buttermilk Falls Limestone and Esopus Shale in easternmost Pennsylvania, in Lehigh Gap area includes Palmerton Sandstone and Bowmanstown Chert.

Dmo

Wills Creek Formation
Greenish gray, thin bedded, fissile shale with local limestone and sandstone zones, contains red shale and siltstone in the lower part.

Bloomsburg Formation
Red, thin and thick bedded shale and siltstone with local units of sandstone and thin impure limestone, some green shale in places.

McKenzie Formation
Greenish gray, thin bedded shale interbedded with gray, thin bedded, fossiliferous limestone; shale predominant at the base; intraformational breccia in the lower part. Absent in Harrisburg quadrangle and to the east.

Keyser Formation
Dark gray, highly fossiliferous, thick bedded, crystalline to nodular limestone, passes into Manlius, Rondout, and Decker Formations in the east.

Sm — **Tonoloway Formation**
Gray, highly laminated, thin bedded, argillaceous limestone, passes into Rosendale and Poxono Island beds in the east.

Dck — **Catskill Formation**
Chiefly red to brownish shales and sandstones, includes gray and greenish sandstone tongues named Elk Mountain, Honesdale, Shohola, and Delaware River in the east.

REFERENCE:
GEOLOGIC MAP OF PENNSYLVANIA PREPARED BY COMMONWEALTH OF PENNA. DEPT. OF INTERNAL AFFAIRS, DATED 1960, SCALE 1" = 4 MILES

GEOLOGY MAP LEGEND

DAPTOLONIA